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## Abstract

This paper examines the response of consumption to income, credit and interest rate changes in Australia. In contrast to previous studies on consumption in Australian, this paper adopts an Euler equation approach. The Euler equation derives from the consumers' utility maximising problem under the assumption that rule of thumb consumers have borrowing restrictions. To assess the role of credit explicitly, credit variables are also included in the Euler equation. The paper further assumes that coefficients are time-varying. The results confirm the significant effects of income and credit on consumption and also reveal that while consumption growth is not responsive to interest rate changes, the coefficient on the real interest rate was time varying and the coefficient becomes smaller in absolute terms since the mid 1990s. This implies that consumption may have been less responsive to interest rate changes since then.



**Key words:** consumption, income, interest rates, credit, liquidity constraints

**JEL classification:** E20, E21, E51

# 1 Introduction

This paper examines the response of consumption to income, credit and interest rates in Australia. Academic research on the determination of aggregate consumption often focus on the life cycle permanent income hypothesis. An important implication of the permanent income hypothesis is that monetary policy can only affect consumption via permanent income. Central banks, however, usually believe that the availability and cost of credit play an important role in consumption decisions of the household sector. They thus pay more attention to the influence of alternative monetary policy measures on credit conditions, which would in turn affect the behaviour of consumption.

One reason why the role of credit is of particular interest to central banks is a perception that higher household borrowing indicates that aggregate consumption is now more responsive to changes in interest rates than has previously been the case. Empirical research, however, has consistently found that consumption displays excess sensitivity to income, i.e., consumption growth is significantly correlated to the growth of current income. This is often attributed to liquidity constraints, which prevent consumers from borrowing against their permanent income. The inclusion credit variables in the empirical study on consumption is therefore a natural extension of the analysis.

Previous studies of consumption in Australia include Tan and Voss (2003) and de Brouwer (1996). Tan and Voss (2003) looks at the relationship between consumption and wealth in Australia. de Brouwer (1996) examines the role of liquidity constraints in consumption in Australia and several East Asian countries. Both studies assume that there is a long run stable relationship between consumption and a measure of permanent income, such as household wealth of others. After identifying the long-run relationship between consumption and permanent income, they estimate the short run response of consumption to income, interest rates and credit variables.

The approach taken in this paper differs from previous studies by following the Euler equation approach adopted in Campbell and Mankiw (1989; 1990; 1991) with additional credit variables for Australia. The Euler equations with fixed coefficients are estimated for different categories of consumption. Moreover, as the response of consumption to these variables may vary over time, coefficients in the consumption equation are further assumed to be time-varying and are estimated by a method proposed by Kim (2004). The paper is organised as follows. Section 2 presents a theoretical framework to derive the Euler equation for estimation. Section 3 describes the data used in empirical work and their time series properties. The estimation results for fixed coefficients are reported in Sections 4 and those for time-varying coefficients are in Section 5. The final section concludes the paper.

# 2 The theoretical framework

This section describes a broad life cycle model as described in Attanasio (1999), to derive a consumption function for estimation. In the life cycle model, a consumer chooses a path of consumption to maximise expected life time utility, subject to an intertemporal budget constraint which requires that the consumer can consume no more than the consumer's permanent income.

The consumer's problem is to choose consumption $C$, to maximise

$$E_t \sum_{i=0}^{T} (1+\beta)^t U(C_{t+i}). \tag{1}$$

subject to

$$W_{t+1} = (1+r_t)W_t + Y_t - C_t,$$

The operator $E_t$ denotes expectations conditional on the information available at time $t$. $W$ is wealth, which pays a rate of return $r_t$ at the end of period $t$.

The consumer receives labour income $Y_t$. The instantaneous utility function $U$ depends on consumption and $\beta$ is the discount rate. A no-Ponzi-game condition is imposed, preventing the consumer from borrowing to finance an increase in consumption today and then borrowing forever to pay the interest on the debt. The Euler equation for this intertemporal optimisation problem is therefore

$$\frac{\partial U(C_t)}{\partial C_t} = E_t\left[(1+r_t)(1+\beta)\frac{\partial U(C_{t+1})}{\partial C_{t+1}}\right] \tag{2}$$

If it is further assumed that the representative consumer has a constant relative risk aversion period utility with Arrow-Pratt measure of relative risk aversion $\gamma$, which is also the reciprocal of the elasticity of intertemporal substitution:

$$U(C_t) = \frac{C_t^{1-\gamma}}{1-\gamma}, \gamma > 0. \tag{3}$$

If one assumes that the rate of returns on wealth and consumption growth are jointly lognormal, then as Hansen and Singleton (1983) showed, the Euler equation simplifies to:

$$\Delta E_t \log C_{t+1} = \alpha + \frac{1}{\gamma}E_t r_{t+1} + \varepsilon_{t+1} \tag{4}$$

A key assumption underlying the life cycle permanent income hypothesis is that consumers can borrow against their permanent income to smooth their consumption path. However empirical research has consistently rejected the permanent income hypothesis. Such rejections are often attributed to liquidity constraints as a large literature has demonstrated that $\varepsilon_t$ is typically predictable and consumption displays excess sensitivity to current income. Campbell and Mankiw (1989; 1990; 1991) argue that a proportion of the population consume its current income so that expected aggregate consumption would depend on expected aggregate income. They term these consumers as rule-of-thumb consumers, and consider the following modified equation:

$$E_t \Delta \log C_{t+1} = \alpha + \sigma E_t r_{t+1} + \lambda E_t \Delta \log Y_{t+1} + \varepsilon_{t+1} \tag{5}$$

where $\lambda$ is a coefficient capturing the excess sensitivity of consumption to current income, and $\sigma$ is a function of $\gamma$ and $\lambda$. Empirical evidence shows that $\lambda$ is usually positive and around 0.5, while $\sigma$ is usually small and insignificant.

A change in interest rates has dual effects on consumption. On the one hand, an increase in the interest rate would encourage consumers to substitute future consumption for current consumption. On the other hand, the income effect of the increase in the interest rate may be ambiguous, depending on whether the consumer is initially a net debtor or saver, and how labour income is expected in the future. Equation (4) implicitly assumes that changes in the interest rate have no effect on permanent income making it difficult to separate the substitution and income effects of interest rate changes in the estimated coefficients of this equation.

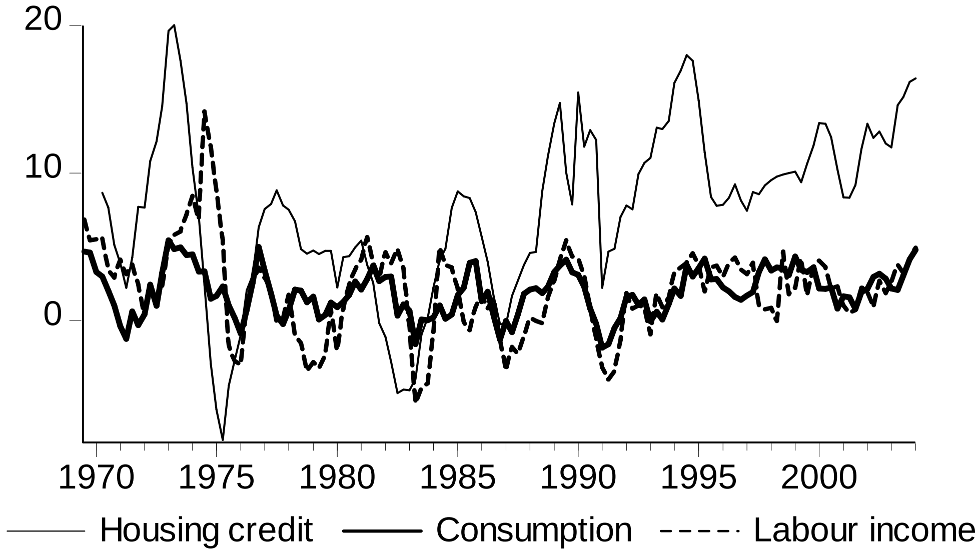
This paper follows Campbell and Mankiw, focusing on the liquidity constraint hypothesis. The study, however, incorporates additional credit variables and time-varying coefficients. Assuming rational expectations, the empirical work is based on equations of the following *ex post* form

$$\Delta \log C_t = \alpha_t + \sigma_t r_t + \lambda_t \Delta \log Y_t + \theta_t \log X_t + \varepsilon_t \tag{6}$$

where $X$ is a credit market indicator, and the coefficients are time-varying.

Before reporting empirical results, it is useful to describe the data used in the study and their time series properties.

Figure 1: Consumption, income and credit in Australia




## 3 Data and time series properties

The data series of consumption and income are quarterly and from the chain volume measure series in the ABS National Accounts. Real per capita measures are computed by using the total population series from the ABS. The empirical analysis uses three measures of per capita household consumption: total, non-durables and non-durables excluding housing services. Previous studies usually identify labour income in consumption equations with total disposable income, such as in Tan and Voss (2003). A literal interpretation of the rule-of-thumb consumers suggests that labour income should be the income these consumers would actually receive. By spending all of their income, rule-of-thumb consumers would not accumulate assets and receive capital income. This paper, therefore, constructs labour income as wages and salaries (compensation of employees) plus transfers minus social contributions for workers' compensation and net non-life insurance premiums, all of which are from the household income account in the National Accounts (ABS Cat.5206.0). The implicit deflator of household consumption is

Table 1: Basic statistics: 1969Q3–2004Q1

| Variables | | Mean (standard error) | Correlation with total consumption |
|---|---|---|---|
| Household consumption | | | |
| | Total | 0.48 (0.75) | 1 |
| | Non-durables | 0.50 (0.69) | 0.93 |
| | Non-durables excl. housing | 0.47 (0.86) | 0.93 |
| Labour income | | 0.50 (1.38) | 0.36 |
| Real interest rate | | 3.12 (4.17) | 0.14 |
| Credit | | | |
| | Housing | 1.89 (1.86) | 0.37 |
| | Other personal | 0.91 (2.49) | 0.21 |

Quarterly growth rates except for the real interest rate.

used to produce the real income series.

The 90 day bill rate, adjusted by the year-ended change in the implicit deflator of household consumption, is taken as the real interest rate in Equation 6. The credit variables used are housing and other personal credit measures in per capita terms, obtained from the RBA and deflated by the private consumption deflator.[1] All the data series are seasonally adjusted, except for the nominal interest rate. Other variables used as instruments, such as unemployment and inflation, are also obtained from the ABS. The sample period is from 1969Q3 to 2004Q1.

Figure 1 plots the year-ended growth of three data series in the sample period: total household consumption, labour income and housing credit in per capita terms. Table 1 shows some statistical properties of the data series to be used in estimation and their correlation with the growth in total consumption. As can be seen, both income and credit growth are correlated with consumption growth with the coefficients of correlation being about 0.4. After financial deregulation in the mid-1980s, credit had experienced much stronger growth than both consumption and income since the late 1980s. The correlation between credit and consumption is likely to rise as the demand for credit and shifts in the availability of credit

[1]The annual credit data before 1976Q3 are obtained from Australian Economic Statistics 1949–1996, published by the RBA, which are then extrapolated to quarterly.

would relax credit constraints and thereby affect consumption. In the mean time, as consumers are less constrained by liquidity, the correlation between consumption and income is expected to fall. In the period 1985 to 2004, the correlation coefficient between consumption and income growth fell to 0.17 while that between consumption and housing credit growth was steady.

The contemporaneous correlation between consumption and credit growth could stem from two sources. One is that changes in credit could be due to shifting expectations of future income, which would in turn change consumption. Alternatively, the correlation arises because the tightness of credit could affect consumers' ability to smooth consumption. Granger causality tests are of interest for reconciling these different explanations and also contain information useful for the interpretation of the estimation results reported below.

Table 2 provides the results from multivariate Granger Causality tests, which are estimated by four-variable VARs (with four lags) incorporating the quarterly growth rates of consumption, income and housing credit, and the real interest rate. Several findings are of interest. First, housing credit tends to lead consumption but not vice versa. Credit, particularly housing credit, is highly correlated with wealth and it is not surprising that when wealth is expected to grow, households would raise their current consumption. In this respect, credit variables can be thought of a proxy of wealth.

Second, the real interest rate leads consumption and income but not credit. This is consistent with the effects of monetary policy on economic activity with lags. There is weak evidence that consumption growth predicts the interest rate, which may indicate that monetary policy reacts to consumption growth. Third, credit on average does a much better job of predicting income growth. This finding suggests that movements in credit do contain much information about future income, therefore, if credit is significant in the following regressions, it could be because credit is correlated with expected income growth.

Table 2: Granger causality test: three measures of consumption

| Marginal significance levels (per cent) | | | | |
|---|---|---|---|---|
| Housing credit<br>1970Q3–2004Q1 | Consumption | Income | Interest rate | Housing credit |
| | | Total consumption | | |
| Consumption | 20.4 | 15.4 | 6.3 | 2.8 |
| Income | 84.5 | 83.3 | 1.0 | 47.5 |
| Interest rate | 6.9 | 12.8 | 0.0 | 87.0 |
| Housing credit | 85.3 | 22.7 | 63.0 | 0.0 |
| | | Non-durables | | |
| Consumption | 39.1 | 76.5 | 3.8 | 8.0 |
| Income | 84.5 | 82.2 | 0.0 | 30.0 |
| Interest rate | 8.4 | 15.8 | 0.0 | 76.8 |
| Housing credit | 64.9 | 28.1 | 67.5 | 0.0 |
| | | Non-durables excluding housing | | |
| Consumption | 37.1 | 74.7 | 8.8 | 6.9 |
| Income | 86.1 | 83.1 | 0.0 | 33.7 |
| Interest rate | 9.9 | 17.3 | 0.0 | 75.7 |
| Housing credit | 76.0 | 22.9 | 69.1 | 0.0 |

| Other personal credit<br>1970Q3–2004Q1 | Consumption | Income | Interest rate | Other personal credit |
|---|---|---|---|---|
| | | Total consumption | | |
| Consumption | 35.1 | 8.2 | 50.0 | 14.4 |
| Income | 75.2 | 93.3 | 0.0 | 81.0 |
| Interest rate | 3.2 | 18.3 | 0.0 | 71.2 |
| Other personal credit | 0.0 | 1.0 | 6.3 | 0.2 |
| | | Non-durables | | |
| Consumption | 48.3 | 48.2 | 38.0 | 28.3 |
| Income | 84.3 | 92.4 | 0.2 | 65.4 |
| Interest rate | 3.2 | 21.1 | 0.1 | 55.2 |
| Other personal credit | 0.0 | 1.0 | 5.2 | 0.2 |
| | | Non-durables excluding housing | | |
| Consumption | 49.7 | 46.8 | 43.0 | 31.1 |
| Income | 82.1 | 92.9 | 0.2 | 67.5 |
| Interest rate | 3.8 | 22.1 | 0.0 | 52.8 |
| Other personal credit | 0.2 | 0.9 | 6.6 | 0.3 |

The Granger causality tests (F tests) are computed from four-variable VARs (with four lags). The rows indicate the dependent variables and the columns the explanatory variables.

For other personal credit (consumer credit), the Granger test results are slightly different. Now income and consumption growth, and interest rates are leading other personal credit growth. This could be due to the difference between housing credit and other personal credit. Housing credit is normally attached to mortgage and therefore is more related to wealth, while other personal credit is more related to credit assessing criteria of financial institutions. As a result, other personal credit tends to lagging consumers' income. In this respect, other personal credit growth could be a better indicator of consumers' liquidity constraints.

Before presenting the method and results of time-varying coefficient estimation for Equation 6, it is useful to briefly discuss fixed coefficient estimates of the equation, since the majority of the empirical studies assumes that the coefficient in consumption equations are constant. The method and estimates of fixed coefficient estimation are reported in an appendix.

In general, the estimates of $\sigma$, the coefficient on the real interest rate, are not significant in every specification. This is consistent with the literature. One exception is Hahm (1998), who finds significant interest rates in the consumption equations similar to the equation without credit variables here. He identifies that 'problematic' housing services may be the source of non-significant responses of consumption to interest rates. The estimation for non-durable consumption excluding housing services in Australia fails to provides a significant $\sigma$. From the derivation shown in the last section, $\sigma$ is actually the elasticity of intertemporal substitution, which captures the substitution effect of changes in the interest rate on consumption over time. It is difficult to separate the substitution effect from the income effect of any changes in the interest rate, even thought the estimation uses instrumental variables.

In all cases except one for other personal credit, the estimates of $\lambda$ are significant at the 5 per cent level, displaying excess sensitivity of consumption to income. The estimates of $\lambda$ in the equations with the credit variables are always smaller than those in the equations without the credit variables. Somewhat surprisingly, the significance of income falls when estimated with the credit variables. The estimates of $\lambda$ range from 0.2 to 0.4 when estimated with housing credit growth and from 0.16 to 0.3 for other personal credit growth. This magnitude is slightly lower than those in Campbell and Mankiw (1989; 1990; 1991).

Most of the estimates of $\theta$, the response of consumption to credit, are significant at the 5 per cent level. The size and significance of these estimates are not systematically different between housing and other personal credit. The presence of credit reduces the estimated sensitivity of consumption to income and always renders its significance to fall. These results support the notion that changes in credit conditions have important effects on consumption.

# 4 Time-varying coefficient estimates

The empirical analysis in the previous section shows that expected future income and credit growth predict consumption growth, which is consistent with the hypothesis that one important determinant of consumption is liquidity constraints. This section introduces another aspect of this hypothesis, that the sensitivity of consumption to liquidity constraints may vary over time, i.e., the coefficients are time-varying. Before presenting the results, this section first discusses the methodology briefly.

Consider the following time-varying-parameter model of consumption growth with the endogenous explanatory variables $\Delta \log Y_t$ and $\Delta \log X_t$:

$$\Delta \log C_t = \alpha_t + \sigma_t r_t + \lambda_t \Delta \log Y_t + \theta_t \Delta \log X_t + \varepsilon_t, \qquad \varepsilon_t \sim N(0, \omega^2_{\varepsilon,t}) \tag{7}$$

$$\alpha_t = \alpha_{t-1} + e_{\alpha,t}, \qquad e_{\alpha,t} \sim i.i.d.N(0, \omega^2_\alpha) \tag{8}$$

$$\sigma_t = \sigma_{t-1} + e_{\sigma,t}, \qquad e_{\sigma,t} \sim i.i.d.N(0, \omega^2_\sigma) \tag{9}$$

$$\lambda_t = \lambda_{t-1} + e_{\lambda,t}, \quad e_{\lambda,t} \sim i.i.d.N(0, \sigma^2_\lambda) \tag{10}$$

$$\theta_t = \theta_{t-1} + e_{\theta,t}, \quad e_{\theta,t} \sim i.i.d.N(0, \sigma^2_\theta) \tag{11}$$

$$\omega^2_{\varepsilon,t} = a_0 \omega^2_{\varepsilon,t-1} + (1 - a_0)\varepsilon^2_{t-1} \tag{12}$$

$$\Delta \log Y_t = z'_t \delta + \omega_v v^*_t, \quad v^*_t \sim i.i.d.N(0, 1). \tag{13}$$

Here $z'_t$ is the vector of either of the two sets of instruments. This set up allows for a time-varying residual variance, which we believe is important given evidence in favour of a reduction in the volatility of output which has occurred during the early 1980s in Australia and several other G7 countries.[2] For now, we treat the relationship between the instrument sets and income growth as constant, although this assumption could easily be relaxed. A similar specification has been estimated by Kim (2004) for US consumption data. However, Kim does not include the interest rate or credit data as regressors and uses a different set of instruments.

As noted by Kim (2004), the conventional Kalman filter cannot be employed to estimate equations (7) to (13), as it is derived under the assumption that the regressors and the disturbance terms are uncorrelated. However as an endogenous regressor is present, the use of the conventional Kalman filter would result in an invalid conditional covariance matrix for the time-varying coefficients.

Kim provides a unified framework to deal with endogeneity problems in the time-varying parameter models. He proposes a two-step procedure that augments the conventional Kalman filter to provide consistent estimates of the hyperparameters, as well as correct inferences on the time-varying coefficients. This is achieved by correcting the conditional covariance matrix from the conventional Kalman filter.

Kim provides a formal treatment of the endogeneity problem in equation (7) by modelling the correlation between the error term $\varepsilon_t$ and the conditional prediction

[2]See, for example, Blanchard and Simon (2001), Simon (2001) and Smith and Summers (2002).

error $v_t^*$ as:

$$\begin{bmatrix} v_t^* \\ \varepsilon_t \end{bmatrix} \sim N \left( \begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{matrix} 1 & \rho\omega_{\varepsilon,t} \\ \rho\omega_{\varepsilon,t} & \omega_{\varepsilon,t}^2 \end{matrix} \right) \tag{14}$$

where $\rho$ is the correlation between $\varepsilon_t$ and $v_t^*$. Kim shows that equations (7) to (14) can be estimated using a two step procedure that makes use of his adjusted Kalman filter. First, equation (13) is estimated using ordinary least squares and an estimate of the standardised residual $\widehat{v}_t^*$ is obtained. Then, the model described by equation (7) is transformed to

$$\Delta \log C_t = \alpha_t + \sigma_t r_t + \lambda_t \Delta \log Y_t + \theta_t \Delta \log X_t + \rho\omega_{\varepsilon,t}\widehat{v}_t^* + w_t, \qquad w_t \sim N(0, (1-\rho)\omega_{\varepsilon,t}^2). \tag{15}$$

and the parameters of (15) and (8) are estimated using Kim's augmented Kalman filter. Details of this procedure may be found in Kim (2004).

Table 3 presents estimates of the model parameters, and Figures 2 and 3 plot smoothed estimates of the time-varying coefficients. Only the results for housing credit are reported because those for other personal credit were found to be similar. Figures 2 and 3 lend some informal support to the hypothesis that the 'excess sensitivity' of consumption growth has fallen since the early 1980's. However, none of the estimates of the standard deviations of shocks to $\alpha$, $\sigma$, $\lambda$ or $\theta$ is significantly different from zero, indicating the time variation in these parameters is not statistically significant.

The coefficient $a_0$ is significantly different from 1 indicating the time variation in the residual variance is statistically significant. In particular, as indicated in Figures 2 and 3, the residual variance appears to be decreasing over time. This indicates that variations in income and credit growth are able to explain a greater proportion of the variation in consumption growth over time. There is very little evidence of exogeneity in equation (7). The estimated coefficient $\rho$ is always negative, but is only significant for the second instrument set of total consumption.

Given the lack of statistical support for the time-varying coefficient specification described above, the model was re-estimated under the restriction that $\alpha$, $\sigma$, $\lambda$ and $\theta$ are constant over time. The results of this exercise are presented in Table 4. From this table we can see that allowing for a time-varying residual variance has very little impact on the parameter estimates presented in Table 5. The estimates of $\sigma$ are not significantly different from zero in every specification but one, the estimates of $\lambda$ are significantly from zero, displaying excess sensitivity of consumption to income. However, the estimated coefficient presented in Table 4 are different from the fixed coefficient estimates from Table 5 in one important respect: the estimates of $\theta$ are not significantly different from zero in every specification. Support for the hypothesis that changes in credit conditions have important effects on consumption is therefore reduced when the assumption of a constant residual variance is relaxed.

# 5 Conclusion

This paper has adopted the Euler equation approach to estimate the response of consumption to interest rates, income and credit. The Euler equation of consumption, derived from the consumer's intertemporal optimisation problem, has been augmented by rule-of-thumb consumers and the credit variables. The consumption equation was estimated with both fixed and time-varying coefficients.

The empirical evidence reported in this study provides strong support to the role of liquidity constraints in the determination of consumption. The credit variables, either housing credit or other personal credit, have been found to be significant in predicting various measures of aggregate consumption. The estimation with time-varying coefficient suggests that financial deregulation did relax the restriction of liquidity on consumption over time. The response of consumption to credit and current income falls gradually. The sensitivity of consumption to

Table 3: Estimates of the rule of thumb model with time-varying parameters: with and without housing credit growth

$$\Delta \log C_t = \alpha_t + \sigma_t r_t + \lambda_t \Delta \log Y_t + \theta_t \Delta \log X_t + \rho \omega_{\varepsilon,t} \widehat{v}_t^* + w_t$$

| Without housing credit | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Category | Inst. list | $\omega_\alpha$ | $\omega_\beta$ | $\omega_\lambda$ | $\omega_\theta$ | $a_0$ | $\omega^2_{\varepsilon,o}$ | $\rho$ |
| Total | 1 | 0.000 | 0.011 | 0.020 | - | 0.936** | 0.989** | -0.011 |
| | | (0.057) | (0.008) | (0.020) | - | (0.014) | (0.180) | (0.297) |
| | 2 | 0.032* | 0.000 | 0.033 | - | 0.901** | 0.995** | -0.518** |
| | | (0.019) | (0.014) | (0.025) | - | (0.030) | (0.172) | (0.253) |
| Non durables | 1 | 0.016 | 0.003 | 0.014 | - | 0.953** | 0.857** | -0.104 |
| | | (0.028) | (0.010) | (0.013) | - | (0.011) | (0.146) | (0.238) |
| | 2 | 0.017 | 0.000 | 0.016 | - | 0.934** | 0.878** | -0.377 |
| | | (0.018) | (0.025) | (0.014) | - | (0.021) | (0.151) | (0.260) |
| Non durables | 1 | 0.023 | 0.004 | 0.017 | - | 0.961** | 1.003** | -0.059 |
| excl. housing | | (0.030) | (0.011) | (0.016) | - | (0.011) | (0.176) | (0.242) |
| | 2 | 0.023 | 0.003 | 0.019 | - | 0.951** | 1.021** | -0.291 |
| | | (0.026) | (0.011) | (0.017) | - | (0.015) | (0.176) | (0.256) |
| With housing credit | | | | | | | | |
| Category | Inst. list | $\omega_\alpha$ | $\omega_\beta$ | $\omega_\lambda$ | $\omega_\theta$ | $a_0$ | $\omega^2_{\varepsilon,o}$ | $\rho$ |
| Total | 1 | 0.015 | 0.013 | 0.012 | 0.013 | 0.935** | 0.916** | -0.291 |
| | | (0.066) | (0.015) | (0.015) | (0.010) | (0.015) | (0.165) | (0.304) |
| | 2 | 0.029 | 0.008 | 0.018 | 0.011 | 0.936** | 0.953** | -0.021 |
| | | (0.028) | (0.009) | (0.016) | (0.009) | (0.015) | (0.167) | (0.302) |
| Non durables | 1 | 0.019 | 0.010 | 0.015 | 0.012 | 0.960** | 0.784** | 0.150 |
| | | (0.035) | (0.009) | (0.013) | (0.010) | (0.012) | (0.146) | (0.266) |
| | 2 | 0.021 | 0.007 | 0.016 | 0.010 | 0.952** | 0.819** | -0.130 |
| | | (0.027) | (0.007) | (0.013) | (0.009) | (0.014) | (0.148) | (0.256) |
| Non durables | 1 | 0.028 | 0.011 | 0.019 | 0.013 | 0.968** | 0.922** | -0.164 |
| excl. housing | | (0.034) | (0.010) | (0.016) | (0.011) | (0.014) | (0.192) | (0.270) |
| | 2 | 0.029 | 0.009 | 0.020 | 0.012 | 0.963** | 0.953** | -0.103 |
| | | (0.029) | (0.008) | (0.016) | (0.010) | (0.013) | (0.182) | (0.258) |

Figure 2: Smoothed estimates of the model parameters without housing credit growth. Solid lines are the parameter estimates for the first instrument set while dotted lines are the parameter estimates for the second instrument set.

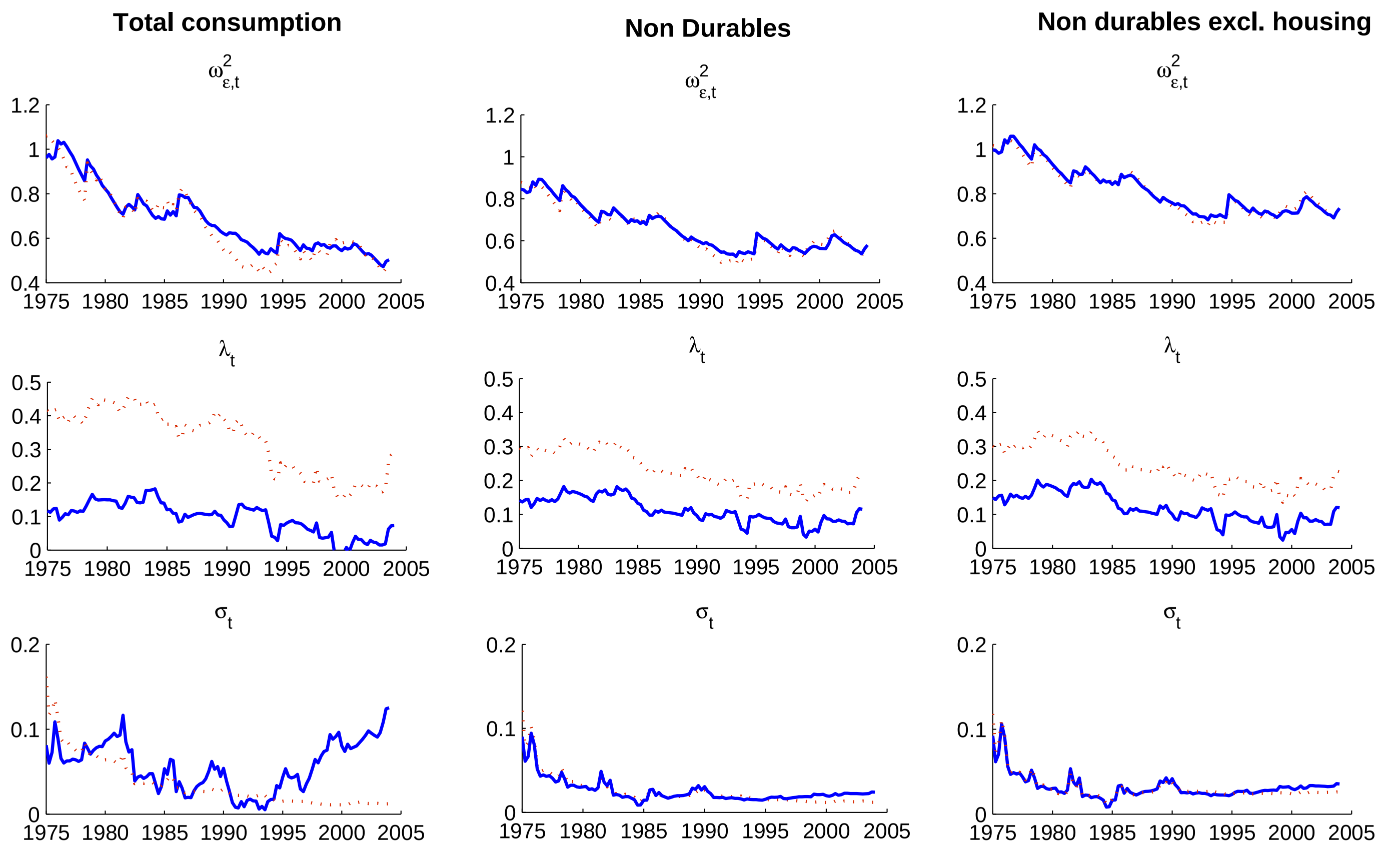


Figure 3: Smoothed estimates of the model parameters with housing credit growth. Solid lines are the parameter estimates for the first instrument set while dotted lines are the parameter estimates for the second instrument set.

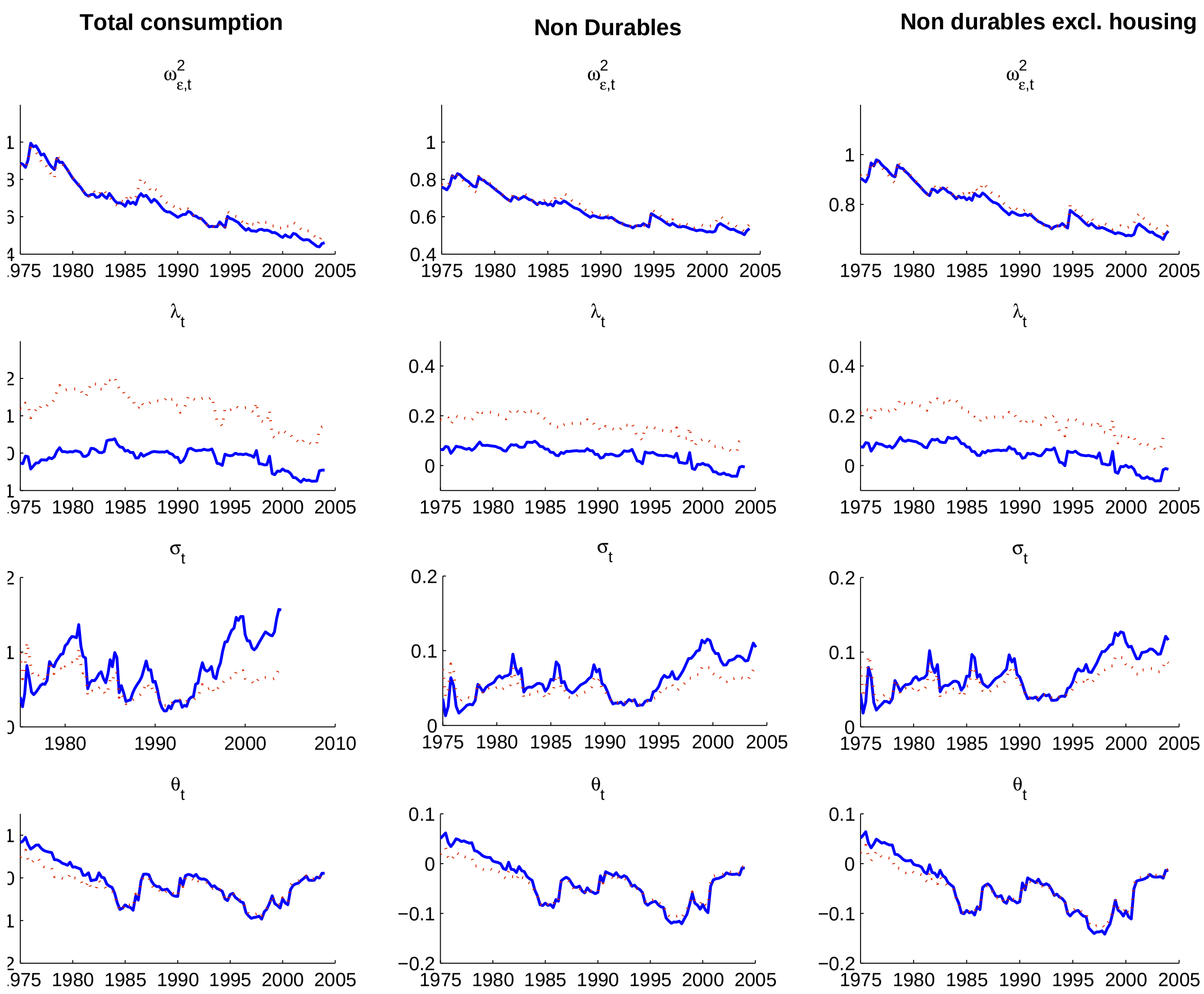


Table 4: Estimates of the rule of thumb model with time-varying variance only: with and without housing credit growth

$$\Delta \log C_t = \alpha + \sigma r_t + \lambda \Delta \log Y_t + \theta \Delta \log X_t + \rho \omega_{\varepsilon,t} \widehat{v}_t^* + w_t$$

| Without housing credit | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Category | Inst. list | $\alpha$ | $\sigma$ | $\lambda$ | $\theta$ | $a_0$ | $\omega^2_{\varepsilon,o}$ | $\rho$ |
| Total | 1 | 0.354** | 0.004 | 0.284** | - | 0.944** | 0.947** | -0.271 |
| | | (0.106) | (0.015) | (0.126) | - | (0.012) | (0.218) | (0.287) |
| | 2 | 0.319** | 0.007 | 0.346** | - | 0.941** | 0.940** | -0.451* |
| | | (0.096) | (0.016) | (0.101) | - | (0.013) | (0.200) | (0.236) |
| Non durables | 1 | 0.377** | 0.007 | 0.240** | - | 0.954** | 0.841** | -0.215 |
| | | (0.096) | (0.014) | (0.113) | - | (0.011) | (0.190) | (0.271) |
| | 2 | 0.337** | 0.010 | 0.314** | - | 0.948** | 0.843** | -0.436** |
| | | (0.087) | (0.014) | (0.088) | - | (0.013) | (0.178) | (0.215) |
| Non durables | 1 | 0.303** | 0.009 | 0.276** | - | 1.000 | 0.808** | -0.127 |
| excl. housing | | (0.106) | (0.017) | (0.112) | - | (0.001) | (0.034) | (0.201) |
| | 2 | 0.260** | 0.016 | 0.370** | - | 0.956** | 0.992** | -0.387* |
| | | (0.110) | (0.017) | (0.115) | - | (0.012) | (0.208) | (0.229) |
| **With housing credit** | | | | | | | | |
| Category | Inst. list | $\alpha$ | $\sigma$ | $\lambda$ | $\theta$ | $a_0$ | $\omega^2_{\varepsilon,o}$ | $\rho$ |
| Total | 1 | 0.360** | 0.005 | 0.224 | 0.025 | 0.946** | 0.943** | -0.156 |
| | | (0.106) | (0.015) | (0.138) | (0.024) | (0.012) | (0.219) | (0.305) |
| | 2 | 0.310** | 0.008 | 0.318** | 0.021 | 0.943** | 0.929** | -0.404 |
| | | (0.100) | (0.015) | (0.117) | (0.023) | (0.013) | (0.202) | (0.275) |
| Non durables | 1 | 0.376** | 0.007 | 0.223* | 0.010 | 0.955** | 0.836** | -0.182 |
| | | (0.096) | (0.014) | (0.120) | (0.023) | (0.011) | (0.190) | (0.281) |
| | 2 | 0.333** | 0.010 | 0.308** | 0.007 | 0.949** | 0.838** | -0.425* |
| | | (0.088) | (0.014) | (0.092) | (0.022) | (0.013) | (0.178) | (0.223) |
| Non durables | 1 | 0.310** | 0.012 | 0.263* | 0.010 | 0.962** | 0.983** | -0.148 |
| excl. housing | | (0.119) | (0.018) | (0.146) | (0.029) | (0.011) | (0.231) | (0.273) |
| | 2 | 0.256** | 0.016 | 0.364** | 0.006 | 0.957** | 0.987** | -0.379 |
| | | (0.112) | (0.017) | (0.119) | (0.028) | (0.012) | (0.208) | (0.235) |

credit suggests that monetary policy could exert powerful effects on consumption by affecting credit, which is also evident in the Granger causality test results that interest rates lead aggregate consumption. The results presented in this paper contrast with those of Tan and Voss (2003), who concluded that their results are difficult to reconcile with the hypothesis that 'the empirical failure of the permanent income and life cycle models are a result of liquidity constrained or rule-of-thumb type consumers' (p.56).

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# Appendix: Fixed coefficient estimates

Because the error term $\varepsilon_t$ in Equation 6 is orthogonal to lagged variables but not necessarily to the regressors in the equation, this paper adopts the instrumental variable method to estimate the equation. As argued by Christiano, Eichenbaum, and Marshall (1991), if consumption decisions are made continuously but the data are measured as time-aggregates, the observed series on spending will follow a first order moving average. As a result, the error term is not necessary to be orthogonal to variables dated $t-1$. To address this problem, Campbell and Mankiw (1989; 1990; 1991) lagged their instruments an extra period (therefore all the instruments are dated $t-2$ or before) and adjusted their test statistics for serial correlation in the residuals. Their estimates of $\lambda$ are around 0.5 and significant from zero.

Another solution, to be used in this study, is to replace the error term $\varepsilon_t$ by $\upsilon_t - \zeta\upsilon_{t-1}$ and to estimate the moving average parameter $\zeta$ explicitly. One can enforce the restriction that any variable dated $t-1$ or before should be orthogonal to $\upsilon_t$, even if it is not orthogonal to $\upsilon_{t-1}$. The advantage of this approach is that the most up to date information can be used in estimation. The fixed coefficient estimation uses two sets of instruments. The first set comprises a constant and four lags each of the regressors (i.e., the real interest rate, consumption growth, labour income growth and credit growth). The second set contains four lags of changes in the unemployment rate and inflation, plus those in the first set.

Table 5 presents fixed coefficient estimates for the Euler equation with or without credit growth. The estimates for housing credit are reported in the top half while those for other personal credit in the bottom half of the table. The test of overidentifying restrictions provides no evidence against all the specifications with either instrument sets.

Table 5: Euler equation with or without credit growth: fixed coefficient estimates

$$\Delta \log C_t = \alpha + \sigma r_t + \lambda \Delta \log Y_t + \theta \Delta \log X_t + \varepsilon_t$$

| Housing credit | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Without credit | | | With credit | | | |
| Category | Inst. list | $\sigma$ | $\lambda$ | Model test | $\sigma$ | $\lambda$ | $\theta$ | Model test |
| Total | 1 | -0.007 | 0.351** | -0.014 | -0.010 | 0.272** | 0.108** | -0.028 |
| | | (0.016) | (0.098) | (0.585) | (0.014) | (0.097) | (0.052) | (0.712) |
| | 2 | -0.005 | 0.242** | 0.017 | -0.011 | 0.203** | 0.134** | -0.030 |
| | | (0.016) | (0.070) | (0.360) | (0.014) | (0.067) | (0.045) | (0.679) |
| Non durables | 1 | -0.455 | 0.339** | -0.062 | 0.653 | 0.294** | 0.051 | -0.062 |
| | | (1.106) | (0.092) | (0.939) | (1.207) | (0.102) | (0.043) | (0.939) |
| | 2 | -0.308 | 0.219** | -0.029 | -0.712 | 0.196** | 0.079** | -0.043 |
| | | (1.091) | (0.056) | (0.678) | (1.202) | (0.051) | (0.031) | (0.767) |
| Non durables excl. housing | 1 | 0.009 | 0.404** | -0.058 | -0.002 | 0.349** | 0.065 | -0.061 |
| | | (0.017) | (0.109) | (0.922) | (0.016) | (0.114) | (0.058) | (0.931) |
| | 2 | 0.002 | 0.270** | -0.038 | -0.003 | 0.236** | 0.097* | -0.054 |
| | | (0.016) | (0.079) | (0.733) | (0.015) | (0.077) | (0.050) | (0.829) |

| Other personal credit | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Without credit | | | With credit | | | |
| Category | Inst. list | $\sigma$ | $\lambda$ | Model test | $\sigma$ | $\lambda$ | $\theta$ | Model test |
| Total | 1 | -0.007 | 0.268** | 0.002 | 0.006 | 0.161 | 0.099** | -0.019 |
| | | (0.016) | (0.098) | (0.446) | (0.013) | (0.099) | (0.038) | (0.634) |
| | 2 | -0.003 | 0.207** | 0.052 | 0.009 | 0.169** | 0.110** | -0.028 |
| | | (0.016) | (0.073) | (0.177) | (0.013) | (0.070) | (0.032) | (0.672) |
| Non durables | 1 | -0.004 | 0.268** | -0.033 | 0.004 | 0.186** | 0.063** | -0.052 |
| | | (0.011) | (0.078) | (0.758) | (0.012) | (0.072) | (0.031) | (0.891) |
| | 2 | -0.002 | 0.204** | -0.003 | 0.006 | 0.166** | 0.075** | -0.056 |
| | | (0.011) | (0.057) | (0.495) | (0.011) | (0.049) | (0.025) | (0.840) |
| Non durables excl. housing | 1 | 0.008 | 0.302** | -0.033 | 0.010 | 0.230** | 0.073* | -0.052 |
| | | (0.017) | (0.110) | (0.760) | (0.015) | (0.112) | (0.042) | (0.888) |
| | 2 | 0.003 | 0.248** | -0.013 | 0.012 | 0.200** | 0.082** | -0.058 |
| | | (0.016) | (0.082) | (0.567) | (0.015) | (0.081) | (0.038) | (0.846) |

Notes: Figures in parentheses underneath $\sigma$, $\lambda$ and $\theta$ are standard errors, assuming MA(1) errors. The column of model test gives the adjusted $R^2$ statistic of a regression of the IV residual on the instruments, with $p$-value for a Wald test of the model in parentheses. All test statistics are heteroskedasticity- and autocorrelation-consistent. * and ** represent significance at the 10 and 5 per cent levels, respectively.